DOCUMENT RESUME

ED 233 532 EC 160 056

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TITLE On Microcomputers, Instruction, and the Severely Developmentally Disabled.
PUB DATE Mar 83
NOTE 60p.; Paper presented at the Council for Exceptional Children Topical Conference on the Use of Microcomputers in Special Education, (Hartford, CT, March 10-12, 1983).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Computer Programs; *Institutionalized Persons; *Microcomputers; *Severe Mental Retardation

ABSTRACT

Use of microcomputers in a state residential facility for nonambulatory profoundly mentally retarded persons is discussed. The effects of such a severe handicap on the residents is examined, and potential contributions of a microcomputer in providing precise contingency control, recording response data, and delivering immediate reinforcement simultaneously for multiple students are discussed. Adaptions of the keyboard and of the output (from textual to various kinds of sensory stimuli) are noted. A summary of client characteristics is followed by description of a pilot test in which a manipulation program was designed according to goals in the residents' individualized education programs. Case study information showing student response is presented along with a discussion of difficulties encountered (including administrator reluctance to spend the money and organizational turf-defensiveness). Details of the computer circuitry and programs are appended. (CL)

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ED233532

ON MICROCOMPUTERS, INSTRUCTION, AND THE SEVERELY DEVELOPMENTALLY DISABLED

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PRESENTED AT
CEC NATIONAL TOPICAL CONFERENCE ON THE USE OF
MICROCOMPUTERS IN SPECIAL EDUCATION
HARTFORD, CONNECTICUT
MARCH 10-12, 1983

EC 160056

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In this presentation we will be sharing regarding some needs we perceive, a bit a fantasy, a challenge, a description of some efforts to address the needs, fantasy, and challenge, some data from those efforts, and then review some problems addressed encountered along the way. We are employed at a state residential facility for mentally retarded persons in West Virginia. As in most such facilities over the past few years, the population has been declining and the proportion of clients who are classified as severely or profoundly retarded has increased concomitantly. At our facility of 410 residents, slightly more than 96% are classified in either of these two categories. The majority of the clients also have other significant handicaps such as major motor impairments, hearing impairments, and seizures. As is well known, regardless of their handicap, all these persons who are school-aged are required to receive individualized educational services according to Public Law 94-142. Additionally, in a facility such as ours there are requirements of provision of active treatment by ICF-MR certification standards, departmental policies, and various professional ethical standards regarding provision of educational and other services. Translating statutory requirements and theoretical statements about provision of services to severely,

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multihandicapped persons into actual, effective services is no small or simple task. As persons charged with the responsibility of converting rhetoric to reality, we are continually on the alert for new means of instruction.

A few years ago a recent development that attracted our notice was the microcomputer. The rapidly evolving microcomputer technology struck us as most promising. The possibility of using a microcomputer as an adjunct to our existing, more traditional instructional procedures seemed quite exciting and viable. The speed, programmable versatility, and small size of the machines suggested several possibilities. Clearly, a microcomputer could be used for administrative purposes such as tracking student progress, generating Individual Education Plans (IEPs) and reports, monitoring compliance with all the P.L. 94-142 requirements, and scheduling services. Development of software for these purposes is clearly valuable and has been done to varying degrees by numerous persons; our interests lay more in the area of applying microcomputer technology in the instructional and stimulation processes.

Clearly, an interest in the use of microcomputers as instructional devices is not unique. There currently are numerous projects utilizing them in this fashion; it is unusual for microcomputers not to be in use in school systems often penetrating down to the elementary level. Indeed, the second edition of the Harvard Gutman Library's Microcomputer Directory: Applications in Educational Settings (1982) documents

the existence of hundreds of such projects. Several commercial instructional packages for microcomputers are presently available e.g., the recent offerings of Contral Data's Plato System. Nor is an interest in use of microcomputers in instruction of special students unique. The index of the Microcomputer Directory lists 57, out of a total of 914, entries under Special Education. (Of course, a sizeable proportion of these projects are utilizing the computers for administrative purposes only.) The applications of Logo for instructional purposes with some special students have been fairly well publicized including coverage in popular perodicals such as BYTE. Most of the Logo applications seem to be with emotionally disturbed or autistic students of normal or near normal intellectual abilities and minimal sensory or physical handicaps. There also appears to be development of some applications with physically and intellectually handicapped persons. However, our analysis has been that the instructional activities with which we are familiar require cognitive skills which are far more advanced than those to be taught our students and increase in complexity too rapidly. We have come to the same conclusion regarding the currently available comercially produced instructional software.

Who are these students who have such special needs? To grossly simplify as noted above, they are the most severely mentally retarded students many of whom have multiple handicaps. We felt that the portion of our resident population most in need of extra attention were those described by Landesman-Dwyer and Sackett (1978) as nonambulatory, profoundly mentally retarded

(NPMR) persons. Table 1 is adapted from their paper and provides criteria for identifying NPMR persons. As might not be surprising based on this information, students classified as NPMR have virtually no self-help skills or language, are only minimally socially responsive, and learn exceedingly simple skills very slowly. A series of studies by Rice and colleagues during the 1960's, e.g., Rice and McDaniel (1966), revealed that students such as these learned even such simple behaviors as arm or head movements or a ring pull in an operant conditioning procedure with great difficulty. Determining reinforcers was extremely difficult and once a behavior increased in frequency, it often unaccountably and precipitously dropped in rate, a phenomenon they called spontaneous extinction. Often the most evident overt behaviors of NPMR students are stereotyped movements such as headrolling, rocking, and repetitive hand, arm, and leg waving. From this rather cursory overview it probably is not difficult to infer some of the types of objectives targeted for NPMR students.

It would be well to take some small amount of time to dwell on the impact these handicaps may present to learning situations. It is likely that the handicaps effect both frequency and complexity of behavior. It is generally agreed that the handicaps may also effect the environmental response to behaviors produced by students of the type with whom we are currently working. The less overt behavior a person emits, the less environmental feedback and interaction with others will occur. This situation stands to result in a further dimunition in

TABLE 1

Characteristics of Nonambulatory Profoundly Mentally Retarded Persons

Physical Size - Very small head and body, typically weight, length, and head circumference below third percentile for chronological age.

Medical Status - Frequently ill with complications requiring extensive medical and nursing attention. Records from the first three years of life indicate little hope for subsequent development or extended survival.

Head Control - Little to no voluntary control.

Sitting Ability - Virtually unable to achieve or stay in a seated position.

Mobility - Even with prothestic devices and extensive training, little movement other than by twisting or turning movements of the body.

General Motor Functioning - Minimal voluntary control with severe neuromuscular impairments obvious.

General Responsiveness - Clear responses to external stimulation being extremely limited at best. Totally dependent on others.

Intellectual Functioning - Untestable or profoundly mentally retarded on standardized assessments.

Adapted from Landesman-Dwyer and Sackett, 1978.

responses, essentially as by extinction, resulting in the personprogressively having fewer skills and being less responsive as well as having greater cumulative behavior deficits relative to more typical behavioral development. This analysis essentially follows those of Bijou (1966) and Lindsley (1965). Motor handicaps may make emission of some behaviors a very strenuous undertaking resulting in low emission rates. In like manner, inappropriate behaviors with a high rate may encourage a very strong environmental response that inadvertently serves to maintain those behaviors, e.g., well-intended attention to stereotypical behaviors and crying may actually maintain those behaviors. Such inappropriate behaviors as may appear as a result of handicaps may be physically incompatible with more adaptive behaviors such as manipulating leisure objects and assisting in self-care routines. Sensory handicaps may preclude the student from experiencing more appropriate behavior models, e.g., a sensory handicap such as blindness limits imitation of many of a model's behaviors. Finally, a handicap may prevent a behavior from occurring at all, e.g., spastic quadriplegia may prevent several motor actions integral to ambulation, self-feeding, dressing. The inability to perform certain behaviors may clearly effect more complex behaviors. Thus, contractures may prevent a person from practicing self-help skills.

Taken from a slightly different perspective, e.g., that of Piaget, the inability of a person to behave in certain ways may seriously limit his sensory-motor learning activities. This, of course, is very critical as it has been argued that events

learned in the sensory-motor stage are important for the occurrence and development of later stages.

Given the severely limited skills and motor abilities of such students, behaviors targeted for instruction often include very simple behaviors. To be more concrete, what would one select to teach a teenaged student with a mental age of 6 months or less, no expressive language skills, minimal responsiveness to conversations, very limited range of motion of all extremities, no mobility skills, no self-help skills, very poor head and trunk control, and most frequent overt motor behavior was head rolling; what would be taught this student? Probably, we would target tracking, responding to being spoken to, and object manipulation. The value of developing such skills may be obvious. Tracking and social responsiveness skills are requisites to many very basic social skills and potentiate enhanced quality and frequency of interaction with others. Development of even very simple object manipulation behaviors promote fine and gross motor development, teaches the student to control the environment, (sounds like circular reactions in Piaget's view), prevents loss of muscle function and responsiveness due to inactivity, and, as suggested by Zuromski (1978), prevents development of learned helplessness. Clearly, commercially available educational software for microcomputers and most of the educational applications of microcomputers, even in special education settings, to date, seem to provide little of relevance for dealing with nonambulatory, profoundly mentally retarded students.

Being impressed with the potential of microcomputer

technology for education and having a substantial number of NPMR students in residence at our facility, we found the possiblity of adapting microcomputer technology to the needs and characteristics of nonambuletory, profoundly mentally retarded persons a great challenge. What did we hope to accomplish in the process? At one level, our intentions were very simple. Primarily, we wanted to increase the rate of occurrence of simple motor behaviors of severely handicapped students. Also, we wanted to assist staff with these students and increase the precision of instruction. Typically, work with these students involves an intensive program of one-to-one teacher-student ratio for instruction. For this instruction to be effective, the teacher must be patient (since responses often occur at quite low rates), be exceedingly consistent, and reinforce target responses instantaneously. Even minute delay greatly diminishes reinforcement effectiveness and hence, rate of response acquisition. Obviously, performing in the indicated manner can be a very demanding, tiring, and repetitive task. Our notion was that a microcomputer should readily provide precise contingency control, record response data, and deliver immediate reinforcement simultaneously for multiple students for some types of behaviors. If such repetitive yet relatively simple tasks could be handled perhaps even with increased precision by the computer, the teacher would be freed for instruction in skills best or perhaps only taught by direct social interaction with other students and the remaining students could remain involved in an instructional or stimulation activity. Clearly, one would

not want to supplant social interaction of nonambulatory, profoundly mentally retarded persons with teachers but rather supplement it.

At this point, let's consider the system we have used in an attempt to address these tasks. In the preponderence of the work to be described here, we utilized an Apple II Plus computer (Dos 3.3) with 48k of RAM, two drives for 5 1/4" minifloppy disks, a video monitor, and a Centronics 779 dot matrix printer. Purchase of this equipment was made possible by a Title IV-C grant from the West Virginia Department of Education. The programs used in the work discussed here were written in BASIC. Needless to say, in deciding to purchase an Apply system, the availability of an extensive amount of well documented software and a substantial number of service outlets were very important to us. Probably all we have done with the Apple could be done with other seemingly cheaper systems but note should be made that much of the ostensive cost savings in doing so would be substantially if not largely offset by the need to purchase expansion interfaces, which would be required to handle necessary peripherals such as dual disk drives, printers, etc.

As probably is apparent from the earlier overview of the students involved in this work, asking them to respond via the typical keyboard arrangement is out of the question due to their motoric limitations. This circumstance gives rise to complications regarding selecting an appropriate response (to be discussed later) and regarding inputing and handling of switch outputs by the computer. A related complication arises in

getting computer outputs in appropriate manner to students. At present the various external switch outputs enter the computer through the game port. Inasmuch as the same response and hence manipulandum or response tranducer would not be expected to be optimal for all students, allowance had to be made for easily and safely changing the manipulanda which were connected into the system. After a few false starts we have settled on an arrangement involving plug connectors for the input from the switches of each student-operated manipulandum. This then goes to an interface which debounces the switch input (preventing a single student response from being mistakenly read by the computer as multiple responses) and serves as an input buffer (storing the response input until the computer acknowledges it). A more detailed formal description of the circuitory involved is provided in Appendix A.

Another part of the system that required some development efforts was the output of the computer to the students. Clearly, textual feedback on a video monitor was irrelevant. Use of the color graphics and audio output seemed promising for some students. However, previous experience suggested that a greater variety of stimuli would be required than these alone would provide. For this reason as well as due to the relatively significant cost of multiple color monitors, we initially opted to use types of stimuli other than those available from a video monitor. Our choice was to have the computer control operation of a variety of devices such as a cassette recorder, hair blower (hair dryer), light display, and a pom-pom afixed to a flexible

rod which could be "flipped" by a solenoid (causing the pom-pom to shake). Since a single stimulus would not be expected to be effective for all students, there was a need for an arrangement for stimulus-producing devices to be easily and rapidly changed. Again, after a number of preliminary attempts, we developed an output interface in which a computer output pulse operated a relay by which a direct connection of the computer and stimulation device was prevented by opto-isolation (removing the possibility of inordinately large voltages feeding back into the computer). The various devices were connected to this interface by standard plug connectors. (Obviously in some cases, e.g., an air blower or a battery-operated toy, some relativly minor alterations in the standard control circuits had to be made to allow remote operation; see Higgins (1982) for a simple description of ways to do this adaptation.) A more detailed description of the circuitry used for this is provided in Appendix A.

The final product of the efforts to deal with the complications discussed above has been a portable system. In order to facilitate ease in use of different instructional spaces and in storage of the equipment, the system has come to rest on a rolling lockable storage unit of the sort typically used for audiovisual equipment. Painted masonite panels have been attached to the sides of the unit by metal brackets. On these panels are sockets for the necessary connectors and accommodations, e.g., brackets, clamps, for affixing the devices used to present stimuli to the students. On back of these panels

are the interfaces and other circuitry as mentioned above.

Now let's shift attention from machines and back to people. Provision of more specific description of students who have participated in our project would be useful. Some summary information on these students is presented in Table 2. First, the table is separated into two groups, Group 1 consisting of seven persons and Group 2 consisting of four persons. The two groups differ by slightly more than three year in chronological age. Column 6 shows that the mental age of the two groups differs quite dramatically with mean mental age for Group 1 being 4 months as opposed to 15 months for Group 2. However, it is not clear with this population of students that mental age is a particularly useful predictor of motor activity production or rate of resonse acquisition. Instead, mental age needs to be considered in light of the total of the handicapping conditins, e.g, in Group 1 the highest mental age person may be the most physically involved.

Before any formal development of manipulanda was undertaken, students who could participate were screened. From this population, the above 11 students were selected. Observations indicated tht each student could move at least one arm. In most cases, both arms could be voluntarily moved though in most cases with a substantially limited range of motion. Only two students could voluntarily move thei. legs and such motions were extremely limited as they lacked sufficient trunk control to produce compensatory movements. All clients, except one, could move

TABLE 2

Table of Client Characteristics

Client	Age	Sex	Sensory Handicap	Motor Handicap	Seizure	M.A.	Functional Level
Macel	15 yrs.	F		Spastic quadriplegia Contractures of Wrist		3 mos.	Profound
Alice	15 yrs.	F	Blind	Limited Leg Use		5 mos.	Profound
Sue	14 yrs.	F		Spastic quadriplegia Hemiparesis	Grand Mal	3 mos.	Profound
Ron	13 yrs.	M		Spastic Diplegia		5 mos.	Profound
Faye	17 yrs.	F		Spastic Paraplegia	Petite Mal	4 mos.	Profound
Al	22 yrs.	M	Hearing Deficit	Spastic quadriplegia		5 mos.	Profound
Lyn	24 yrs.	F		Spastic quadriplegia		4 mos.	Profound
Fred	22 yrs.	M		Spastic quadriplegia		17 mos.	Profound
Ray	21 yrs.	M	Strabismus	Hip Dislocation		23 mos.	Profound
Herb	19 yrs.	M		Spastic paraplegia, Hip dislocation	General Motor	17 mos.	Profound
Eloise	21 yrs.	F		Paraplegia		4 mos.	Profound

their heads in all directions. All observations were coraborated by consultations with a registered physical therapist. From this population, then, the following response pool was available; Group 1 - Reaching, pulling, grasping, head rotation, biting, scratching or rubbing and nodding. In a few cases, leaning was also available. Group 2 - Reaching, pulling, pushing, grasping, head rotation, head nodding, biting, scratching, or rubbing, leaning, and squeezing.

Originally, Group 1 was selected as it was anticipated that by dealing with the most severely mentally retarded students, the limits and ultimate capabilities of microcomputers in instruction of NPMR could be readily and clearly determined. Indeed, this test appears now to have not provided us with sufficient information to make a definitive statement. The characteristics of the groups that are shown in Table 2 do not tell the entire story. With the exception of three persons, most members of Group 1 regularly produced behaviors we felt could be increased in terms of frequency and complexity. Group 2 was selected as an alternative demonstration. Members of this group differed from Group 1 in mental age but they also had many similar physical handicaps. Actual initiation of activities was not begun simultaneously with all students. The first efforts were with a couple of Group 1 students. In our eagerness to commence, we began exploratory efforts with these students, while capabilities to handle multiple students simultaneously, varied response inputs, and varied stimulus outputs were being developed. Gradually, all Group 1 students were added and served in the

afternoons. This, in turn, was followed by initiation of computer-managed activities to Group 2 during mornings.

The selection of responses for utilization was finally limited to those behaviors we felt most probable given a student's handicap, current sensory-motor development, which were not reflexive in nature, and had eventual functional utility. This last point may need further clarification. In several cases, especially among members of Group 1, students seemed physically capable of reaching for, grasping, and retrieving objects, e.g., toys, but did not. Indeed, they very well might not even do so when such objects were availalbe in very close proximity. Thus, in terms of setting the occasion for improving sensory-motor operations and exploration behaviors, as well as possibly improving upon some rudimentory forms of play, it was decided that the target behaviors should encourage reaching, grasping, and perhaps retrieval. For Group 1, such a combination initially seemed best produced in the form of a pulling response.

Members of Group 2, however, showed a fair capacity for retrieval of toys as well as exploration behaviors but not, as a rule, prolonged involvement with objects. Thus, while most members of this group reached out and retrieved play objects and at least minimally manipulated objects, play itself was a very low rate response. In fact, all group members revealed only limited exploration, retrieval, and play. Thus, for members of Group 2, it was decided that a simple pull response, already available at considerable rates in some of their repertoires, might not be an optimal choice. Rather, it was determined that

behaviors of this group should demonstrate more complexity. Arm movements should be accompanied by hand movements, e.g., reaching, grasping, holding, and moving needed to be part of the behavioral complex up to the limits of each group members' ability.

A brief description of the manipulanda used for our students probably would be helpful. For members of Group 1, the manipulandum initially consisted of a light weight string to pull. More specifically, a piece of fishing line was attached to the microswitch at one end and to a plastic cuff at the other. The student completed a pull response by simply flexing his/her arm or he/she could grab the string with either hand and pull on it. This manipulandum was used initially for all members of Group 1. For members of Group 2, three different manipulanda were used: rotating cylinder, an omnidirectional joystick, and a joystick connected to an adjustable goose neck stand. The rotating cylinder (actually a modified rolling pin) was used to encourage hand as well as arm movements, although, as designed, the rolling pin could be moved by simply dragging one's hand across the barrel of the rolling pin. The rolling pin was anchored to a stand and screws were placed in one end of the rolling pin in such a manner as to depress a microswitch when the pin was turned. To prevent direct manipulation of the microswitch by the student, plastic covers were placed over the end of the cylinder and the microswitch. This manipulandum was then clamped to a tray that could be placed within arms reach of the students. Eventually this manipulandum was used with three

of the Group 1 students who had very low rates of the string-pull response.

The joystick and joystick mounted on a gooseneck were purchased from the Prentke-Romich Company of Shreve, Ohio. Like most omnidirectional joysticks, microswitches could be activated by pushing, pulling, or otherwise moving the stick out of the center position. Each stick was spring-action controlled to return to the center of the manipulandum when released. Additionally, the joystick mounted on the gooseneck could be twisted and angled to conform to the particular capability of a student. Each manipulandum was capable of accomodating high response rates and forces as well as a variety of manipulation forms. Each of these devices were then anchored to trays which could be placed within the reach of each student. We also have a number of other manipulanda which could be used, e.g., wobble switch, air cushion, pneumatic (pillow) switch, and pneumatic switch requiring either sucking or blowing into a tube.

In Figure 1 are some samples of generalized IEP objectives which we have found adequate to apply to training with these responses. The particular response criteria, whether a percentage or frequency measure, type of prompts, e.g., verbal, gestural, physical guidance, and type of any other reinforcers, e.g., social, edible, would have to be specified. Obviously, goals such as these would just comprise a portion of a student's objectives. They would have to be integrated into the total plan of educational and related services.

EXAMPLE GOAL STATEMENTS

Reaching toward object ___ % of time with ___ prompts and ___ reinforcers during a 2-week period.

Grasps object producing auditory and visual stimulation ___ % of time with ___ prompts during a 2-week period.

Grasps object producing auditory stimulation ___ times per session with ___ prompts during a 2-week period.

Grasps object producing visual stimulation ___ % of time with ___ prompts during a 2-week period.

Moves toy or manipulandum ___ times per minute with ___ prompts and ___ reinforcers during a 2-week period.

Uncovers toys or manipulanda ___ times in five minutes with ___ prompts and ___ reinforcers during a 2-week period.

FIGURE 1

One topic of enormous import to be considered prior to our having begun the actual training with the computer was that of selection of response consequences. While it may be true that some persons of this population may perform fairly well for edibles and drinkables, we decided to take a different tactic. Our decision to use other consequences was based upon three factors: 1) logisticly speaking, our current training location and equipment do not lend themselves to use of edible consequences very well; 2) consumables are indeed consumed requiring a constant supply, and additionally; 3) there often is a significant delay between occurrence of target response and the actual consumption of the reinforcer. For these reasons, we elected instead to concentrate on the production of sights, sounds, and other stimulus events as consequences. Initially, we felt that we should captialize upon hearing and visual skills in the response consequences we provided. Thus, we used shaking a pom-pom and having a series of lights sequence through or "chase themselves around" a circular configuration. For others, we provided music and spoken stories via cassette tapes. Later we provided activation of the lights and sounds from a space gun (originally battery-operated) and softly blowing air from a hair dryer without the heating element as consequences. To date, we have found the blowing air and spoken stories to be the most effective of our consequences. This is not to say that other visual, auditory, or vibratory events will not be effective, but rather, with the persons we have tried to date, they have not been as effective as we had hoped. We will, of course, continue

to keep these various consequences in our armementarium while we explore the effectiveness of others. Also, we have not as yet tried every combination of consequence with all students. It is important to note, however, that we have not as yet systematically explored varying durations or onset/offset parameters.

At this time it would be well to discuss our techniques for chosing a particular response consequence for a given student. After obtaining our base rate of behaviors, the student is provided with a variety of stimuli, e.g., music activation of the space gun, one a a time. We observe closely for obvious signs of disress, e.g., frowning, crying, withdrawing, for orienting responses, e.g., eye opening, cessation of movement, head or eye movement in the direction of the stimulus if spatially localizable, and overt positive affective responses, e.g., smiling and laughing. The event eliciting the least signs of distress and the most orienting and positive affective response is tried first as an ostensive reinforcer. Presently we are attempting to formalize and empirically evaluate this procedure.

To ensure that at least some initial contact is made with the consequences, we haved used a priming technique. In this technique, before a training session begins, the instructor operates the apparatus which will present the stimuli used during training as response consequences, e.g., the cassette player is operated, presenting a brief sample of the music or story being

used. This priming technique is used daily when student response rates may be low. In the case of some students priming only had to be used one or twice.

Having discussed the computer system utilized, the students involved, and the selection of responses and consequences, an overview of the actual instructional session seems in order. The instructor turns on the system, loads the relevant program disk, then goes through a start-up dialogue (shown at the top of Figure 2). During this dialogue the students involved in the upcoming sessions are indicated as well as whether baseline or intervention, i.e., response contingent stimulation is in effect, the type of reinforcement schedule to be used, and maximum session duration. Then when this is completed, as is appropriate for each student, the stimulus-devices to be used are connected and positioned, e.g., on one of the side panels of the unit holding the computer, the appropriate manipulanda are secured and connected, and the student placed facing the appropriate side panels. The students are then checked for appropriate positioning in their wheelchairs (as indicated by a physical therapist) and then the manipulanda are placed in front on the studen either clamped to a lap tray or affixed to a modified hospitaltray if a student does not use a lap tray. Once all is in order, the instructor starts the session then remains nearby to provide monitoring of the students. Presently, we have been providing three, five-minute sessions per day with each student (barring illness or system malfunction). Brief sessions are used to ensure that the instructor continues to interact frequently

Start-up Dialogue

```
JPER#01 [redacted]
2  [redacted]
3  [redacted]
4  [redacted]
5  [redacted]
6  [redacted]
7  [redacted]
8  [redacted]
9  NULL
10 TESTDAT
11 ABORT

SCHEDULE FOR KEY 1
ENTER FILE NO.  CLIENT ID NULL FILE
CONDITION NO. 1
CONDITION TOTALS
SESSIONS 0  TRIALS 0

SESSION DATA
NO. OF TRIALS 3
TYPE  OF SCHEDULE FR100
DURATION OF REINFORCEMENT 1
WHAT IS THE MAXIMUM SESSION LENGTH (IN MINUTES)CLIENT ID TEST FILE
CONDITION NO. 1
CONDITION TOTALS
SESSIONS 0  TRIALS 0

SESSION DATA
NO. OF TRIALS 300
TYPE  OF SCHEDULE FR1
DURATION OF REINFORCEMENT 3
WHAT IS THE MAXIMUM SESSION LENGTH (IN MINUTES)
 JGOTO 620
PRESS RETURN TO START
```

End of Session Output

```
THIS DATA IS FOR [redacted]  THE SCHEDULE WAS AN FR1.
TOTAL TRIALS= 0  TOTAL RESPONSES= 3
TOTAL TINE= 1 MIN.  AND 0 SEC.
RESPONSES PER MIN. =3


THIS DATA IS FOR [redacted]  THE SCHEDULE WAS AN FR1
TOTAL TRIALS= 1  TOTAL RESPONSES= 1
TOTAL TINE= 1 MIN.  AND 0 SEC.
RESPONSES PER MIN. =1

DO YOU WANT TO RUN MORE SUBJECTS (Y,N) N

PROJECT ORION DISK
```

Figure 2

with the student, i.e., we do not want to "park" a student in front of a machine and then "forget" him, and to provide opportunity for repositioning any student who may move into an inappropriate position in his/her wheelchair during a session. At the end of a student's third daily session the data are stored on disk and then output on the monitor as shown in the lower portion of Figure 2. A complete listing of the program is provided in Appendix B.

Some sample student data will illustrate some of our progress to data. One of the very first students to be involved in this project was Macel. The response utilized was the pull-response which was used exclusively in beginning (in part due to not having better alternatives at the time). The response consequence used was 4 seconds of music. Data for each five minute session are presented in Figure 3. After a period of baseline conditions (no programmed response consequences) with considerable session-to-session variability in response rate, response-contingent presentation of stimulation had no clear, systemmatic effect. The most remarkable effect was the large range in response rates. Beginning at session 287 there was a fairly short-lived increase in response rate during sessions with contingent-stimulation, however, it is unclear whether the eventual decrement in rate was an instance of "spontaneous extinction" or merely a return to low rates following brief high rate sessions as had occurred earlier. At present, we are exploring use of alternative manipulanda and response-contingent stimuli. In retrospect, we think, perhaps, we should have taken

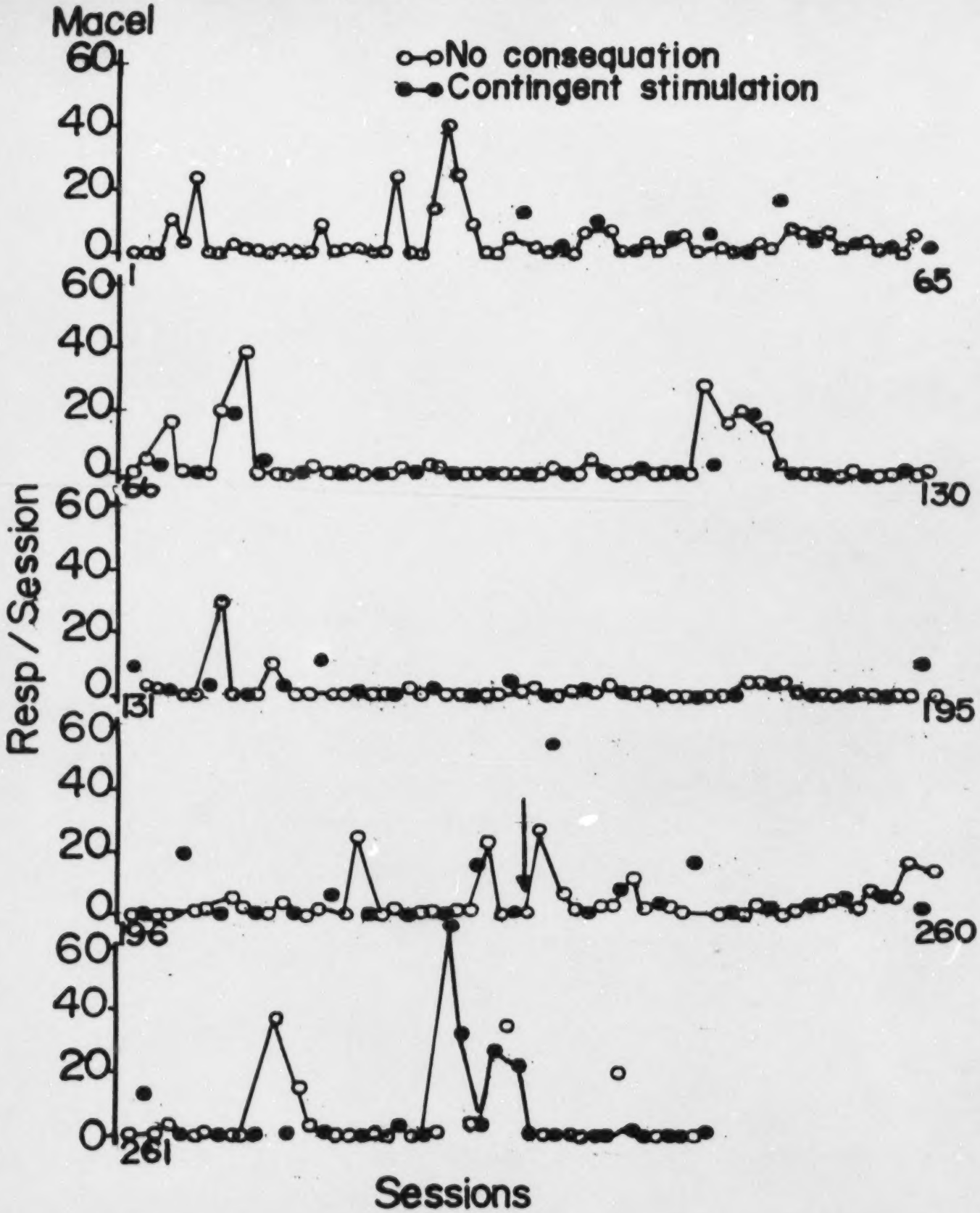
Macel
No consequation
Contingent stimulation
Resp / Session
60
40
20
0
1
65
66
130
131
195
196
260
261
Sessions

Figure 3

this tactic earlier. However, this tactic was not taken during the earlier period of work with Macel since we were just developing some of the other devices and capability and then later when rate increased for a session or two we were hoping an overall trend in the direction of increased rate would evolve. Perhaps it is worth noting that transient rate increases during contingent stimulation sessions occurred at session 229 when the priming procedure was introduced and following the change to two rather than one contingent stimulation sessions daily beginning at session 285.

As with Macel, response rate varied considerably between sessions during the initial phase when baseline conditions were used exclusively with Ray (see Figure 4). The frequency of response, in this case, use of the rotating cylinder switch, increased over that in baseline conditions when each resulted in presentation of a recorded story for 4 seconds. Rate clearly decreased when baseline conditions were reinstated in session 55, then rose again when contingent stimulation was reinstituted in session 60. It is interesting to note that response rate clearly dropping during session 46 (indicated by a triangle in Figure 4) when the cassette player malfunctioned part way through the session.

Rate of use of the joystick switch by Eloise is shown in Figure 5. No change in response rate is evident subsequent to response-contingent stimulation, i.e., four seconds of music, becoming available. Inasmuch as virtually no responses occurred during this latter phase, the instructor began attempting to

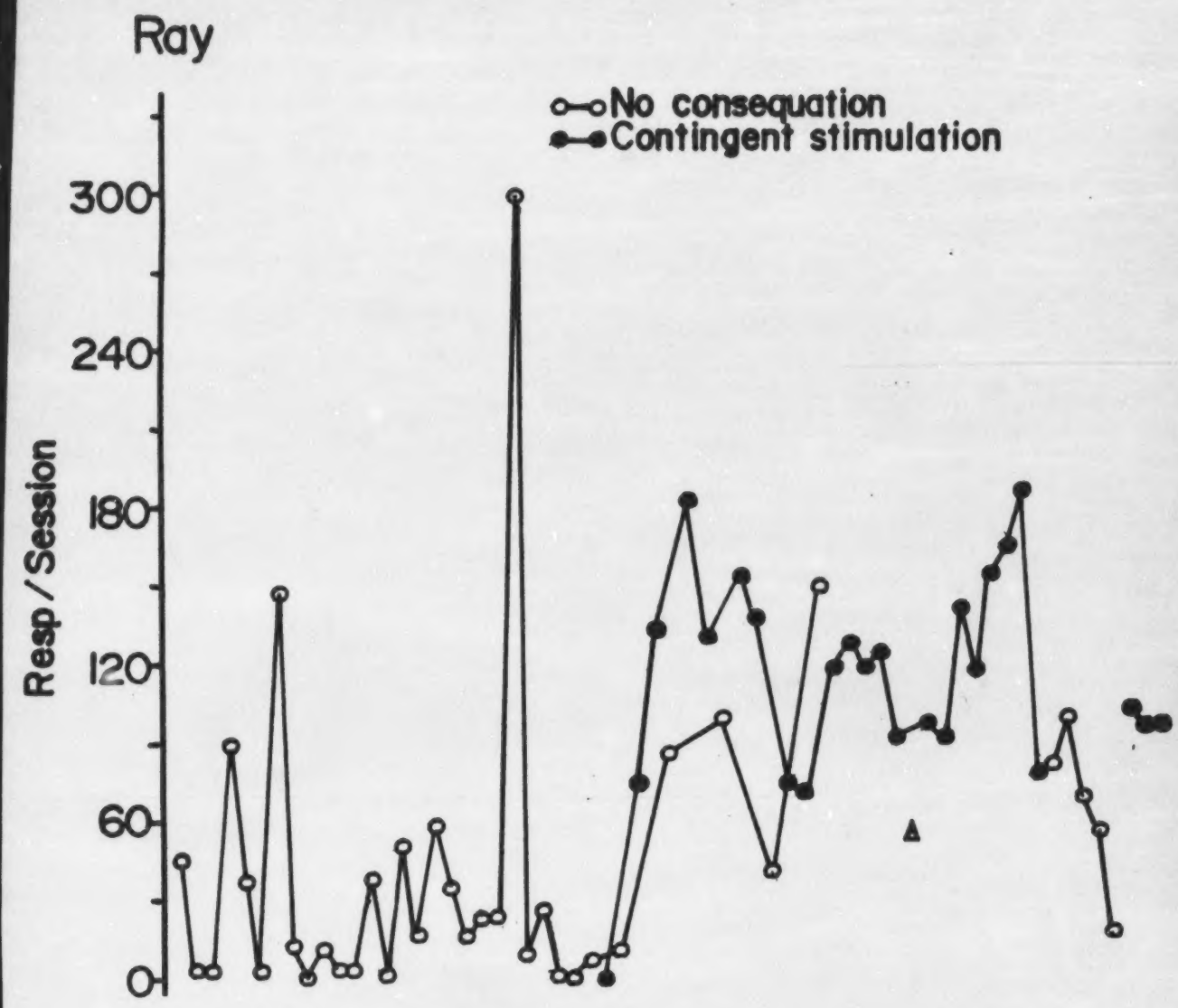
Ray
No consequation
Contingent stimulation
300
240
180
120
60
0
Resp/Session

Figure 4

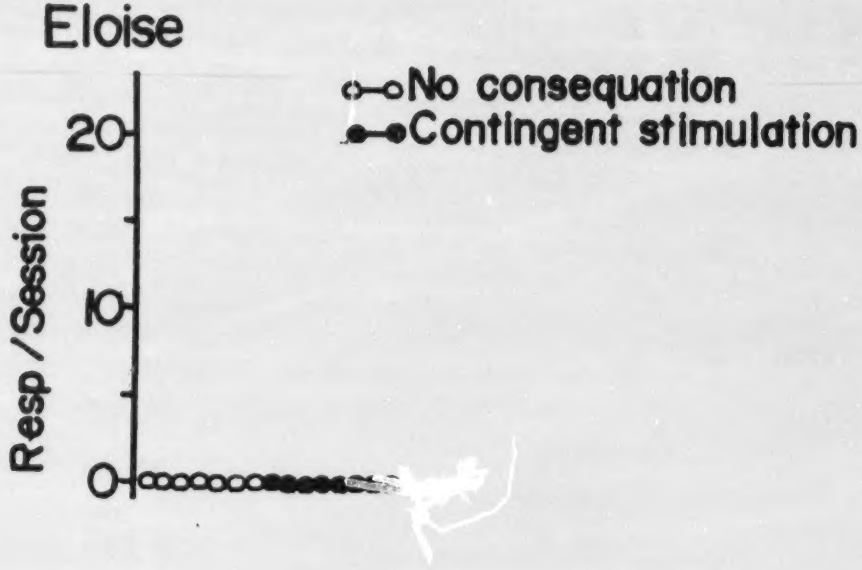
Eloise
No consequation
Contingent stimulation
Resp/Session
20
10
0

Figure 5

shape the response by activating the cassette player upon occurrence of hand or arm movements in the direction of the joystick (these would not be shown as resonses on the graph, however). This strategy has not been effective. Conseqently, we are re-evaluating what responses and what type of contingent stimuli to use with Eloise.

Herb's rate of using the rotating cylinder manipulandum is shown in Figure 6. Response rate was low during baseline conditions then increased when switch activation produced 4 seconds of activation of the space gun. The increase in rate was transient, unfortunately. Consequently, other types of response consequences are now being tried since the response per se does not seem to be problemmatic. The reason for the precipitous drop in rate is unclear but it does seem to be an instance of the phenomenon previously termed spontaneous extinctions.

A final set of data are shown in Figure 7. Here only a few sessions were required for a very clear demonstration of the effectiveness of the procedures. Rate of utilization of the rotating cylinder manipulandum increased when it produced 4 seconds of operation of the air blower, then rapidly decreased when contingent stimulation was discontinued. With contingent stimulation re-instituted response rate again increased. We anticipate moving to some simple discrimination tasks with Fred in the near future.

Due to time and space constraints, data for all participating students have not been presented. The presented

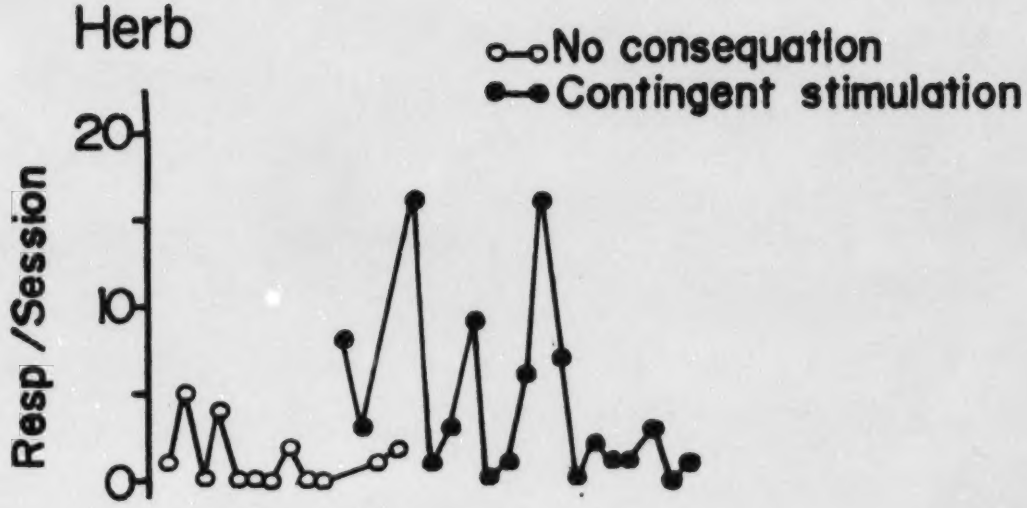
Herb
No consequation
Contingent stimulation
Resp /Session
20
10
0

Figure 6

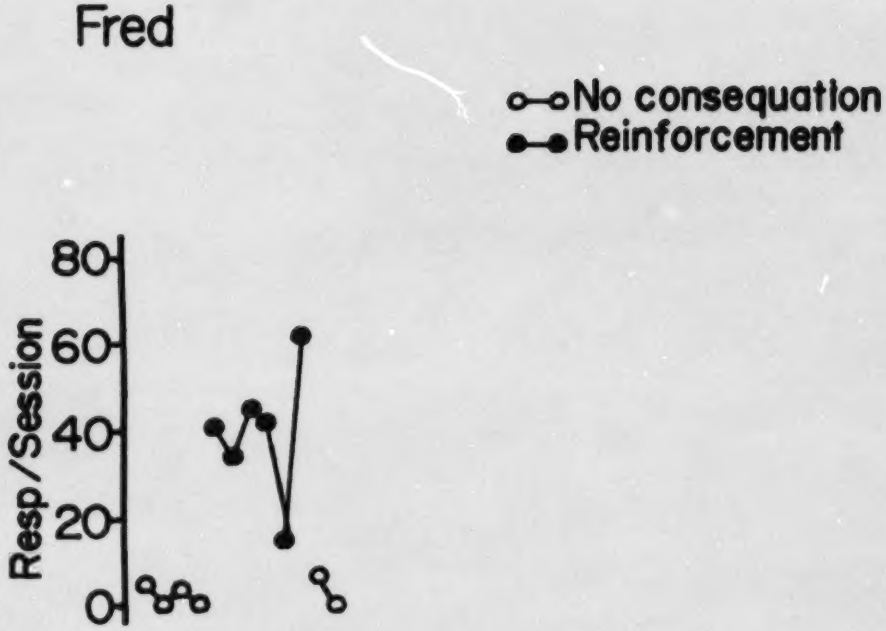
Fred
No consequation
Reinforcement
Resp/Session
80
60
40
20
0

Figure 7

data do however illustrate the effects (or lack thereof) we have observed. In some instances, e.g., Macel and Eloise, we have been frustrated in attempts to generate consistent increases in the rate of productive behaviors. In other instances, e.g., Herb's, response rate increases were transient. How to predict or circumvent such occurrences is as yet unknown to us. Finally, we have seen some unequivocal increases in rate, e.g., Ray and Fred. We are convinced that a system involving a microcomputer can be effectively utilized in precisely and consistently conducting training of simple behaviors which can enhance motor and, potentially, cognitive skills, providing the students something constructive to do, and, at least partially, relieving an instructor of a tedious, repetitive task. We attribute the lack of progress by some students not to inadequacies of the computer system but in the state of our knowledge about effective instruction with NPMR students.

Having told why we were interested in the use of microcomputers in Special Education with nonambulatory, profoundly mentally retarded students, what we proposed to do, how we attempted to do it, and some of the accomplishments, we want to share some of the difficulties we encountered and suggest some precautions. One of the first difficulties we encountered and, in these times of economic austerity, we suspect others will also encounter, was locating funding for and permission to purchase the equipment. Some administrators are predisposed to view microcomputers as a faddish gimmick, the latest "A-V toy", which will quickly be stuck on a shelf and not used. Why spend

the money on something which may be of little use in instruction (perhaps due to lack of staff who know what to do with it) and will be a dust collector? One suggestion is to attempt to obtain funding from private contributions or special fundraisers. At one of our children's school, contributions from businesses and collection of Campbell's soup label have helped provide microcomputers. Another source is small grants such as the Title IV-C grant which funded the equipment for this project. Either of these strategies avoid encroachment on local revenues. On the other hand, persons proposing purchase of a microcomputer should be prepared to provide a realistic projection of potential applications and trained staff. Additionally, overselling should be avoided and latent difficulties acknowledged. A dose of humility probably will be helpful in convincing skeptical administrators who are concerned about conserving funds.

Another difficulty we encountered was organizational turf-defensiveness. We discovered that the staff responsible for operation of the large computer systems which handled personnel information, payroll, inventory, etc., had some very pointed opinions about facilities such as ours purchasing microcomputers. Some of these concerns included: What possible use could we have for a computer? Who did we have that knew anything about computers? Why should money be spent on buying a number of cheap little, and from their perspective, dinky, light duty machines that wouldn't hold up well? Finally, and seemingly most substantially, why didn't we just let them handle whatever it was we wanted to do with their large, powerful machines? Needless to

say, since the opinion and recommendation of these computer specialists were important to the administrators who approved purchase, we began attempting to inform them of the capacities of microcomputers, of the specific applications of interest, of the necessity of immediate access to and output from a computer used for instruction, and of the uselessness for our purposes of reports of student activity which arrived even a day after the fact. We gave numerous assurances, both oral and written, that we would not develop an information management system which would rival or duplicate any of their activities. In retrospect, perhaps we were a bit naive in not having spent more time with the people dealing with the large systems before we began developing our proposal.

A third set of difficulties we encountered pertained to system development. Along this line, we have encountered difficulties with systems operating as we though we had been assured they would. We discovered that it is possible that some microcomputer salesmen, with apparent backing by their "technical people", sometimes give firm assurances that software will operate with a particular disk-operating system or that specific components or boards are compatible and can be utilized simultaneously when such is not the case in a straight forward manner. To illustrate, in development of a separate system we were assured that speech recognition, synthetic speech, and color graphics packages could all be simultaneously available for operation in an instructional manner with another microsystem

with the available memory and simple BASIC programs. We found such to clearly not to be the case, at least without substantial and expensive software development. For what it's worth, we were dealing with a firm specifically recommended by the manufacturer as having expertise in such matters. Probably everyone was operating in good faith and ultimately all the components probably could be made to functin as we wanted, given enough time and money. However, one should recognize that people may be operating under very different perspectives and time frames when addressing the question, "Can component A and component B be utilized together in a XYZ microsystem?" Most of us educational users want to know, "Can we plug them in, turn on the power, and tell them to go?" Dealers and technicians may really be saying, "Sure it'll work ultimately, but there may be some considerable adaptations needed first."

Another circumstance we have encountered relative to difficulties in system development is that all components are not readily available off a shelf. As noted above, for instructional applications such as with students we discussed here, adequate software is not readily commercially available. If you are contemplating an application similar to ours, you need someone fluent in BASIC or whatever programming language you plan to use. The time needed to develop such software should not be treated as minimal; it can be considerable. The more sophisticated things wanted from a system, the more time will be required for program writing and testing. If an adequately skilled programmer is not on staff, the propriety of developing a microcomputer system

should be viewed skeptically unless a firm commitment can be obtained from a consultant or someone such as a person affiliated with a nearly college or university program. Similarly, as noted above, we have found a need for some relatively simple electronic circuits which had to be fabricated. Again, time and some money needs to be allowed for this purpose. If an adequately skilled person is not on staff, proceed very cautiously. A commitment from an adequately trained person from somewhere is essential given our experience.

A fourth class of difficulties we have encountered pertains to maintenance and repair of the equipment. Inevitably, things quit working! Keys on terminals will stick. The heads on disk drives will need to be adjusted. Wires on switches will come off. Pins will break on connectors. Connections may tarnish or corrode. Sometimes systems do not seem to realize that manufacturers assure consumers that the machines will perform well with only minimal attention to temperature and humidity. The occurrence of many of these problems seems exacerbated if one is deceived by the size of microcomputers into thinking they are highly portable and frequently moving them about. Having a skilled technician on staff, or readily available to deal with such problems, is essential. Having a maintenance contract is highly desireable but don't let having one lead to smug confidence. Unless the contractor is very nearby and makes "housecalls" on short notice, a problem that develops may not be resolved immediately and may necessitate some transportation of the malfunctioning components to the repair shop. Also, for what

it is worth, precautions will be needed to minimize the likelihood of damage to the system by students grabbing cables, housekeeping staff bumping components with or engaging cables on dustmops, buffers, or by deliberate vandalism; if not theft. Clearly secure storage is essential.

Our experience has been such that we all have become believers in Murphy's Law; just about anything that could go wrong with the system, has done just that at some point. For a while this situation caused us to be rather doubtful of our competence. However, after learning that other persons who seemed to have even more computer sophistication than we had voiced some similar concerns (Kieras, 1981; Mayer, 1981; Schneider, 1981) we didn't feel so bad.

A final set of difficulties in developing a microcomputer system for instruction with nonambulatory profoundly mentally retarded students pertains to student characteristics rather than the computer system per se. As noted earlier selections of an optimal response and optimal reinforcer for each student are difficult. Many of these students have such physical handicaps that determination of which motor activities are possible, particularly witout inadvertently eliciting counter-productive reflexes, is difficult. A priori specification when the number of different, clearly voluntary movements and rate of occurrence of each is so low, is difficult. In some cases, the range of motion and the flexibility of the limbs is very limited. Clearly, consultation with a physical therapist and/or occupational therapist is essential. However, sometimes the

advice of such skilled specialists is to try working with a given movement and see what happens. While we have not finalized the process, our practice is to position each of a number of manipulanda one at a time in front of a student and obseve which is activated at the highest rate (alert low in an absolute sense). Selecting what to use as an ostensive reinforcer is, if anything, even more problematic. With less severely handicapped persons determinations of reinforcers is simpler since they often can indicate preferences among activities and stimuli by means of language, gestures, or even actual approach. With the greatly limited language and motor abilities of students such as those involved in this project, such indications are not very likely. Similarly, a clear demonstration of the effectiveness of some stimulus or activity as a reinforcer for some other behavior generally is not readily available; this fact was one of our concerns in starting this project. At present we are finalizing a formal procedure for assessment of reinforcer effectiveness with these students.

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ACKNOWLEDGEMENTS

Much of the financial support for this work was provided by ESEA Title IV-C grant DEV 5601-80-0. The administrative support of W.E. Richards, Administrator, and the Continuing Medical Education Committee (Research Review) are greatly appreciated. The efforts of Kirk Lockwood, Joe Lancaster, and Chris Price in the embryonic stages of this project are gratefully acknowledged. Holly Brown's efforts in manuscript preparation are acknowledged as absolutely invaluable. Molly Watson's artistic talents in figure preparation and Vicki Kyle's assistance in manuscript assembly were irreplaceable. The presence and influence of the Ikon are also acknowledged. Finally, the opinion contained herein are those of the authors and not necessarily those of the West Virginia Department of Education or Department of Health.
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APPENDIX A

Circuitry

Interface Hardware
INPUT

At times the use of the traditional double throw micro switch for response input is inconvenient or impractical. Using integrated circuit (IC) technology a simple interface can be constructed which will debounce and latch almost any switch.

The circuit described here is constructed using 74LS TTL series ICs but can be built using 74C series CMOS ICs. One sixth of a 74LS14 Schmit trigger is used along with a resistor and a capacitor to debounce the input, then one half of a 74LS74 D type Flip-Flop is used as a latch. A schematic of the basic circuit is shown in figure 1. If your input voltage requirement is greater then 5 volts, figure 2 shows an opto isotator added as an input buffer that can be used for this RX1 must be varied according to the voltages used. As only one sixth of the 74LS14 and one half of the 74LS74 are used the circuit can be repeated so that one 74LS14 and three 74LS74s can interface six inputs (figure 3).This circuit can be connected directly to the three one bit inputs of the apple II computer or to the inputs of most microcomputer parallel port boards without requiring a software timing loop for switch debounce .

The circuit can be wire wrapped or point to point soldered on a printed curcuit board. Inputs are expected to be pulled high by R1 and to swing to gnd. when a switch is closed (see ref. one for use with a n.c. switch or CMOS ICs). The latch requires a positive pulse to reset it after the input has been read. As shown in figure 3 multiple inputs can be ored together with a 74LS32 quad OR gate for an interrupt or read port strobe so that the control system does not have to continually test the port for an input. Remember that all unused IC inputs must be tied to V+ or gnd and that at least one .01MF disk capacitor should be used for every two ICs for despiking.

OUTPUT

Stimulus output circuits for use with microcomputers must be designed differently then those used in a relay based system. First, the outputs should be electronically isolated from the computer. This is necessary in order to prevent potentially damaging voltages IE higher then +5 volts or lower then gnd. from entering the computer and to prevent electrical noise interference. This isolation is provided by an opto-isolater such as a 4N33. Second, since a microcomputer output is normally limited to +5 volts at perhaps 20 ma. the signal must be amplified in order to operate most stimulus devices. A transistor amp can only drive relatively small direct current loads but a 2N2222 transistor can in turn drive a small 5 to 12 volt relay or a 2N3055 relay can drive a standard 24 volt relay (figure 4).

An alternative device called a solid state relay contains an

opto-isolater and a triac and will control several amps at up to 120 volts but can only be used with alternating current. While a transistor such as the 2N3055 can be used to directly drive many types of stimuli it may still be preferable to use a relay as your output in situations where a general purpose interface is needed or where technical assistance is not available. Remember that when using opto isolators the input ground must not be electricahly connected to the output ground, that is, there is no electrical connection between the input and output or you will defeat the purpose of the device.

References

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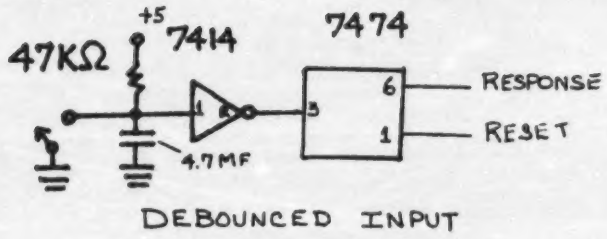

+5
47KΩ
7414
7474
RESPONSE
RESET
4.7MF
DEBOUNCED INPUT

Fig. 1

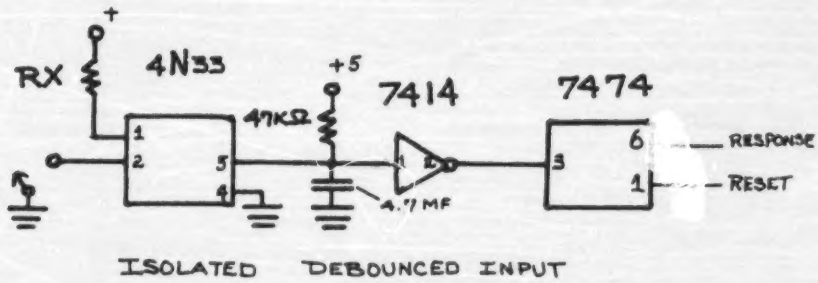
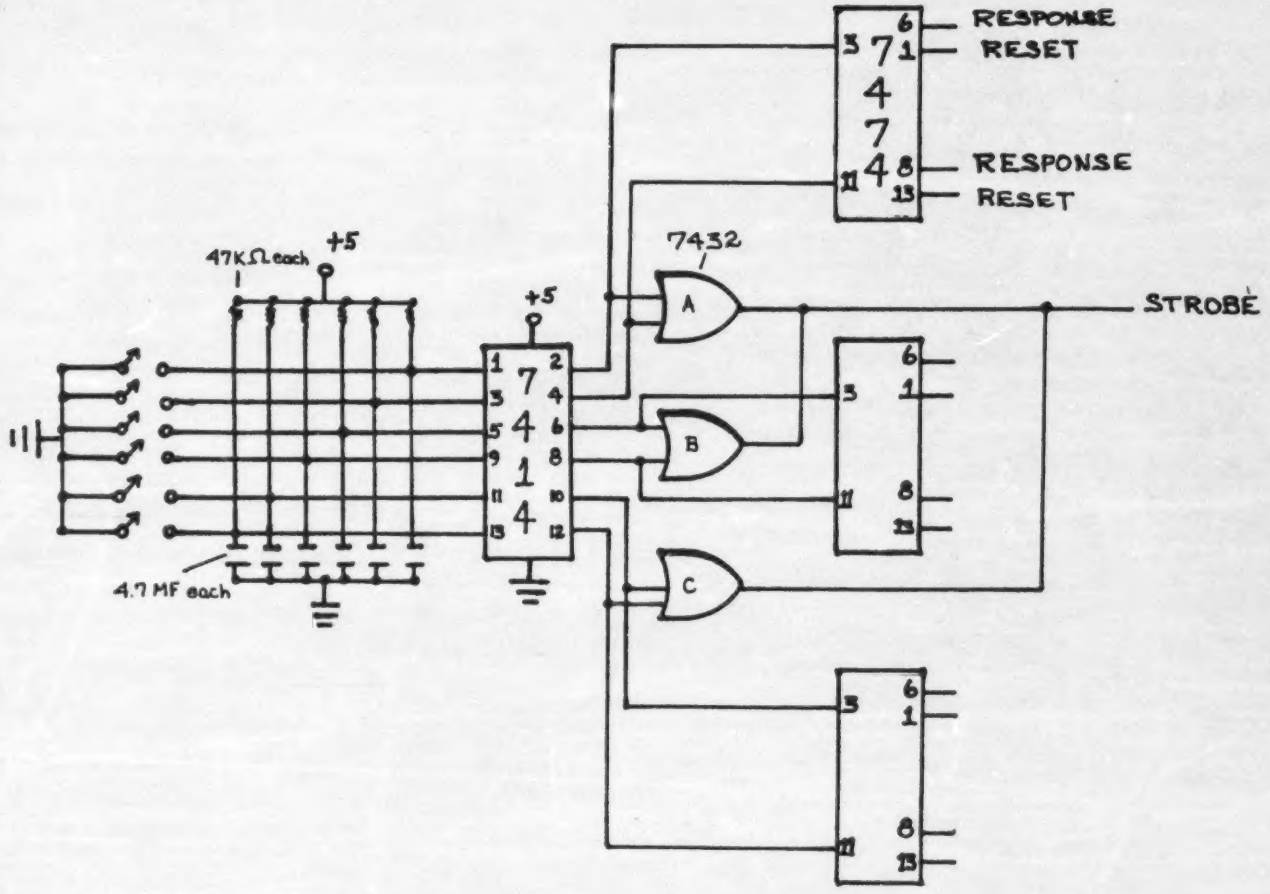
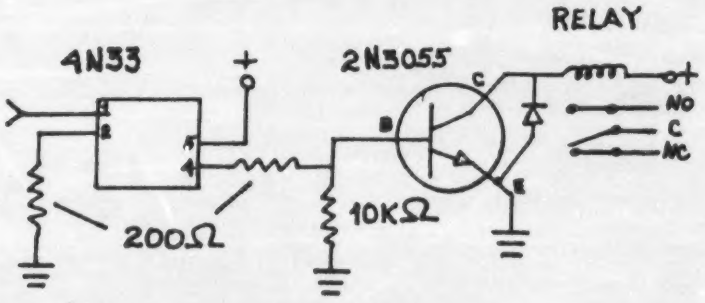

RX
4N33
+5
7414
7474
47KΩ
RESPONSE
RESET
4.7MF
ISOLATED DEBOUNCED INPUT

Fig. 2



MULTI-SWITCHED DEBOUNCED INPUT

Fig. 3



ISOLATED OUTPUT BUFFER

Fig. 4

Table 1
List of components

	Figure no. 1	2	3	4
opto isolator 4N33				
Resistors 1/4W				
47Kohm	1	1	6	
Capacitors				
4.7MF electrolytic	1	1	6	
.01 disc for despiking	1	1	2	
Transistors				
2N2222 or				1
2N3055				
Integrated Circuits				
74LS14	1	1	1	
74LS74	1	1	3	
74LS32			1	
Relay				
RS 273-213 5V or				1
24V lab type relay				

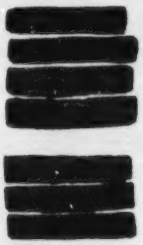
APPENDIX B

Program Listing

```
PROJECT ORION DISK


THE PROGRAMS ON THIS DISK ARE
1                ORION 2.0
2                TEST 1.0
3                MAKE HEADER
4                GET HEADER
5                PRINT DATA
6                END
ENTER THE NUMBER OF YOUR SELECTION 30987
CLOSE
11611
1
2
3
4
5
6
7
8
9                NULL
10               TESTDAT
11               ABORT

SCHEDULE FOR KEY 1
```



```
ENTER FILE NO.
]LIST

100  REM  MENU 3/1/81
110  REM· PROJECT ORION
120  HOME : VTAB 3
130  ONERR  GOTO 350
140 X = 6
150 D$ =  CHR$ (4)
160  PRINT "PROJECT ORION DISK "
170  PRINT
180  PRINT
190 A$(1) = "ORION 2.0"
200 A$(2) = "TEST 1.0"
210 A$(3) = "MAKE HEADER"
220 A$(4) = "GET HEADER"
230 A$(5) = "PRINT DATA"
240 A$(6) = "END"
250  PRINT "THE PROGRAMS ON THIS
     DISK ARE "
260  FOR N = 1 TO X
270  PRINT N, A$(N)
280  NEXT N
290  INPUT "ENTER THE NUMBER OF Y
     OUR SELECTION ";K
300  IF K = 6 THEN  END
310  HOME : VTAB 3
320  PRINT "WAIT "
330  PRINT D$;"RUN "A$(K)
340  END
350  REM  ERROR ROUTINE
360  PRINT  CHR$ (7): PRINT
370  PRINT "ERROR "; PEEK (222);"
      TRY AGAIN"
380  GOTO 160
```

DEVELOPED AS A PROJECT OF COLIN ANDERSON CENTER
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```
]LIST

100  REM  MAKE HEADER
110  REM  PROJECT ORION
120  REM   CREATE DATA FILES
130 D$ =  CHR$ (4)
140  HOME : VTAB 3
150  INPUT "FILE NAME ";A$
160 B$ = A$
170  INPUT "DO YOU WANT NEW DATA
     FILES (Y,N)";H$
180  IF H$ = "N" THEN  GOTO 230
190  PRINT  CHR$ (7);"WARNING THI
     S WILL ERASE OLD INX,DAT AND
      IRT FILES. "
200  INPUT "CONTINUE (C) OR ABORT
      (A)";Y$
210  IF Y$ <  > "C" THEN  GOTO 44
     0
220 DA = 0:A8 = 0
230  INPUT "ENTER CLIENT'S NAME "
     ;N$
240  INPUT "ENTER THE CONDITION N
     O.  ";M
250  PRINT "ENTER SCHEDULE AS TYP
     E,VALUE,NO. OF TRIALS "
260  INPUT RC$,RC,T
270  INPUT "ENTERTHE DURATION OF
     REINFORCEMENT IN SECONDS ";D
     UR
280  PRINT A$,N$
290  PRINT "SCHEDULE ";RC$;RC;"
     TRIALS  ";T
300  PRINT "COND ";M;"  DUR";DUR
310  INPUT "IS THIS CORRECT (Y,N)
       ";Y$
320  IF Y$ <  > "Y" THEN  GOTO 15
     0
330  PRINT D$;"OPEN ";A$
340  PRINT D$;"WRITE ";A$
350  PRINT N$: PRINT M: PRINT RC$
     : PRINT RC: PRINT T
360  PRINT DUR
370  PRINT D$;"CLOSE ";A$
380  IF H$ = "N" THEN  GOTO 440
390 A$ = B$ + " INX"
400  PRINT D$;"OPEN ";A$;",L10"
410  PRINT D$;"WRITE ";A$;",R0"
420  PRINT DA: PRINT A8
430  PRINT D$;"CLOSE ";A$
440  INPUT "MORE ENTRIES? (Y,N)";
     Y$
450  IF Y$ = "Y" THEN  GOTO 120
460  PRINT D$;" RUN MENU"
```

DEVELOPED AS A PROJECT OF COLIN ANDERSON CENTER
FUNDED BY WEST VIRGINIA DEPARTMENT OF EDUCATION ESEA IV-C 5601-80-0

```
]
]LIST

100  REM   ORION 3/31/83
110  REM  MAIN PROGRAM
115  REM  GAME PORT VERSION
120  REM  ESIA TITLE IV-C
130  REM  SET D$=CTRL-D FOR DISK
     CONTROL
140  CLEAR
150  REM  A4= NO. OF NAMES
160 A4 = 11
180 D$ =  CHR$ (4)
200 SN = 2: REM   NO. OF STATIONS

210  DIM AF$(16)
220  DIM AN$(16)
230  DIM RX(300,SN)
250  DIM IRT%(300,SN)
260  DIM RN(300,SN),TN(300,SN)
270 REIN(1) = 49241:REIN(2) = 492
     43
280 STIM(1) = 49245:STIM(2) = 492
     47
300 GT = 0
310  REM
320  REM  ******************
330  REM  CLEAR OUTPUTS
340  FOR I = 1 TO SN
350 A1 =  PEEK (STIM(I) - 1):A1 =
      PEEK (REIN(I) - 1)
360  NEXT I
370  REM
380  REM  ********************
390  REM  CLIENT FILE LIST
400 AN$(1) = [redacted]
410 AN$(2) = [redacted]
420 AN$(3) = [redacted]
430 AN$(4) = [redacted]
440 AN$(5) = [redacted]
450 AN$(6) = " "
460 AN$(7) = " "
470 AN$(8) = " "
480 AN$(9) = "NULL"
490 AN$(10) = "TESTDAT"
500 AN$(11) = "ABORT"
510 STI ) = 49216
520  REM
530  REM  ********************
540  GOSUB 760: REM      GET COND
     ITION DATA
550  GOTO 570
560  GOSUB 1140: REM    RESET COU
     NTERS
```

DEVELOPED AS A PROJECT OF COLIN ANDERSON CENTER

FUNDED BY WEST VIRGINIA DEPARTMENT OF EDUCATION ESEA IV-C 5601-80-0

```
570 GT = GT + 1
580 XX(1) = 1:XX(2) = 1
590  FOR I = 1 TO SN
600  IF X$(I,GT) = "B" THEN XX(I)
      = 2
610  NEXT I
620  INPUT "PRESS RETURN TO START
     ";A1$
630  GOSUB 1270: REM  START SESSI
     ON
640  GOSUB 2240: REM  UPDATE HEAD
     ER
650  GOSUB 2090: REM  PRINT SUM D
     ATA
660  PRINT
670  IF GT < 3 THEN  GOTO 560
680  INPUT "DO YOU WANT TO RUN MO
     RE SUBJECTS (Y,N) ";A1$
690  REM
700  REM  **********************
710  IF A1$ = "Y" THEN  HOME : GOTO
     120
720  PRINT D$;"RUN MENU": REM  GO
      BACK TO MENU
730  REM
740  REM  **********************
750  REM  SET UP EXP.
760  FOR Z = 1 TO A4
770  PRINT Z; TAB( 5);AN$(Z)
780  NEXT Z
790  FOR I = 1 TO SN
800  PRINT
810  PRINT "SCHEDULE FOR KEY ";I
820  REM  SET FOR TRIAL 1
830 TT(I) = 1
840  INPUT "ENTER FILE NO.   ";Z
850  IF AN$(Z) = "ABORT" THEN  GOTO
     2770
860 AF$(I) = AN$(Z)
870  PRINT D$;"OPEN ";AF$(I)
880  PRINT D$;"READ ";AF$(I)
890  INPUT N$(I),CO(I),RC$(I),RC(
     I),N(I),DUR(I)
900  PRINT D$;"CLOSE "AF$(I)
910 NX$(I) = AF$(I) + " INX"
920  PRINT D$;"OPEN ";NX$(I);",L1
     0"
930  PRINT D$;"READ ";NX$(I);",R0
     "
940  INPUT DA(I),A8(I)
950  PRINT D$;"CLOSE "NX$(I)
960  PRINT "CLIENT ID ";N$(I)
970  PRINT "CONDITION NO.  ";CO(I)

980  PRINT "CONDITION TOTALS "
990  PRINT "SESSIONS ";DA(I);"  T
     RIALS ";A8(I)
1000  PRINT
1010  PRINT "SESSION DATA "
1020  PRINT "NO. OF TRIALS ";N(I)
```

```
1030  PRINT "TYPE  OF SCHEDULE ";
     RC$(I);RC(I)
1040  PRINT "DURATION OF REINFORC
     EMENT ";DUR(I)
1050  INPUT "WHAT IS THE MAXIMUM
     SESSION LENGTH (IN MINUTES)"
     ;TMAX(I)
1060  PRINT "ENTER COMPONENT CODE
     S IE A,B,A"
1070  INPUT X$(I,1),X$(I,2),X$(I,
     3)
1080  PRINT : PRINT
1090 SES = SES + I
1100 TMAX(I) = TMAX(I) * 60
1110 SES(I) = 1
1120  NEXT I
1130  RETURN
1140  REM  RESET COUNTERS
1160  REM
1170  REM  **********************
1174  FOR I = 1 TO SN
1180 X(I) = 0:T(I) = 0:R(I) = 0
1182 TE(I) = 0:TI(I) = 0:TT(I) =
     1
1190 RTM(I) = 0:TR(I) = 0:SES(I) =
     1
1200 SES = SES + I
1210  NEXT I
1220 TC = 0:SCK = 0:MIN = 0:N = 0
     :NN = 0:NM = 0
1230 T = 0
1240  RETURN
1250  REM
1260  REM  **********************
1270  REM  LOOK FOR INPUT
1280 A1 =  PEEK (STRB)
1290 DC = DC + 1
1300  IF SES <  = 0 THEN  RETURN

1310 B1 =  PEEK (49249)
1320 C1 =  PEEK (49250)
1330 D1 =  PEEK (49251)
1340  IF B1 > 127 THEN  GOSUB 138
     0
1350  IF C1 > 127 THEN I = 1: GOSUB
     1750
1360  IF D1 > 127 THEN I = 2: GOSUB
     1750
1370  GOTO 1290
1380  REM
1390  REM
1400  REM  **********************
```

```
1410  REM  OUTPUT STROBE
1420 A1 =  PEEK (STRB)
1430  REM  INCREMENT TIMERS
1440 TC = TC + 1
1450  IF TC < 3 THEN  GOTO 1640
1460 T = T + 1
1470 TC = 0
1480  IF T / 12 =  INT (T / 12) THEN
     A1 =  PEEK (STIM(1))
1490  IF T / 60 =  INT (T / 60) THEN
     MIN = MIN + 1: GOSUB 2010
1500  FOR I = 1 TO SN
1510 X(I) = X(I) + 1
1520  REM
1530  REM  ***********************
1540  REM  TICK
1550 A1 =  PEEK ( - 16336)
1560 RTM(I) = RTM(I) - 1
1570  IF RTM(I) <  = 0 THEN A1 =
      PEEK (REIN(I) - 1)
1580  IF SES(I) = 0 THEN  GOTO 16
     20
1590 T(I) = T(I) + 1
1600 TE(I) = TE(I) + 1
1610  IF T(I) = TMAX(I) THEN TT(I
     ) = TT(I) - 1: GOSUB 1980
1620  NEXT I
1630 A1 =  PEEK (STIM(1) - 1)
1640  RETURN
1710  REM
1720  REM  OUTPUT STROBE
1730  REM
1740  REM  ********************
1750 A1 =  PEEK (STRB)
1760  IF SES(I) = 0 THEN  GOTO 20
     00
1770 TR(I) = TR(I) + 1
1780 IRT%(TR(I), I) = X(I):X(I) =
     0
1790 R(I) = R(I) + 1
1810  IF R(I) < RC(I) THEN  GOTO
     2000
1820  REM
1830  REM  ************************

1840  REM  END OF TRIAL
1850  IF XX(I) = 1 THEN  GOTO 188
     0
1860 RTM(I) = DUR(I)
1870 A1 =  PEEK (REIN(I))
1880 N = TT(I)
1890 RN(N, I) = R(I)
1900 TI(I) = TI(I) + TE(I)
1910 TN(N, I) = TE(I)
1920 TE(I) = 0
1930 R(I) = 0
1940  IF TT(I) < N(I) THEN TT(I) =
     TT(I) + 1: GOTO 2000
```

```
1950  REM
1960  REM  **********************
1970  REM  CLEAN UP AFTER DONE
1972 A1 =  PEEK (STIM(I) - 1):A1 =
     PEEK (REIN(I) - 1)
1974  IF R(I) = 0 THEN TT(I) = TT
     (I) - 1
1980 SES(I) = 0
1990 SES = SES - I
2000  RETURN
2010  REM
2030  PRINT  CHR$ (7): REM  RING
     BELL
2040  PRINT MIN;"  MIN."
2050  PRINT "KEY 1= ";TR(1);"  KE
     Y 2= ";TR(2)
2060  RETURN
2070  REM
2080  REM  ************************
     *
2090  REM  PRINT DATA
2100  PRINT  CHR$ (7); CHR$ (7); CHR$
     (7)
2110  REM
2120  REM  PRINTOUT
2130  FOR I = 1 TO SN
2140  PRINT : PRINT
2150  PRINT "THIS DATA IS FOR ";N
     $(I);"  THE SCHEDULE WAS AN
     FR";RC(I)
2160  PRINT "TOTAL TRIALS= ";TT(I
     );"  TOTAL RESPONSES= ";TR(I
     )
2170 NN =  INT (T(I) / 60):NM = T
     (I) - (NN * 60)
2180  PRINT "TOTAL TIME= ";NN;" M
     IN.  AND ";NM;" SEC."
2190  PRINT "RESPONSES PER MIN. ="
     ;TR(I) / (T(I) / 60)
2200  NEXT I
2210  RETURN
2220  REM
2230  REM  **********************
2240  REM  UPDATE HEADER
2250  FOR I = 1 TO SN
2260 DA(I) = DA(I) + 1:A8(I) = A8
     (I) + TT(I)
2270  REM
2280  REM  ************************
```

```
2290  REM  INDEX FILE
2310  PRINT D$;"OPEN ";NX$(I);",L
     10"
2320  PRINT D$;"WRITE ";NX$(I);",
     R0"
2330  PRINT DA(I): PRINT A8(I)
2340  IF DA(I) = 1 THEN R1 = 0:R2
     = 0: GOTO 2370
2350  PRINT D$;"READ ";NX$(I);",R
     ";DA(I) - 1
2360  INPUT R1,R2
2370  PRINT D$;"CLOSE ";NX$(I)
2390  GOSUB 2490
2400  PRINT D$;"OPEN ";NX$(I);",L
     10"
2410  PRINT D$;"WRITE ";NX$(I);",
     R";DA(I)
2420  PRINT R1: PRINT R2: PRINT X
     $(I,GT)
2430  PRINT D$;"CLOSE ";NX$(I)
2440  NEXT I
2450  RETURN
2460  REM
2470  REM   **********************
2480  REM  DISK DATA
2490 NN$(I) = AF$(I) + " DAT"
2500  PRINT D$;"OPEN ";NN$(I);",L
     10"
2510  FOR N = 1 TO TT(I)
2520  PRINT D$;"WRITE ";NN$(I);",
     R";R1 + N
2530  PRINT RN(N,I): PRINT TN(N,I
     )
2540  NEXT N
2550  PRINT D$;"CLOSE ";NN$(I)
2560 R1 = R1 + TT(I)
2570  IF TT(I) = 0 THEN R1 = R1 +
     1
2580  REM
2590  REM  ***********************
2600  REM  IRT DATA TO DISK
2610 IR$(I) = AF$(I) + " IRT"
2620  PRINT D$;"OPEN ";IR$(I);",L
     5"
2630  FOR X = 1 TO TR(I)
2640  PRINT D$;"WRITE ";IR$(I);",
     R";R2 + X
2650  PRINT IRT%(X,I)
2660  NEXT X
2670  PRINT D$;"CLOSE ";IR$(I)
2680 R2 = R2 + TR(I)
2690  RETURN
2700  END
2710  REM
2720  REM  ***************************
```

```
2730  REM   ERROR CORRECTION
2740 EA =  PEEK (222)
2750  IF EA <  > 5 THEN  GOTO 279
     0
2760  PRINT "ERROR REENTER FROM B
     EGINING "
2770  PRINT "WAIT"
2780  PRINT D$;"RUN ORION"
2790  PRINT "ERROR ";EA
2800  END
```

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]

]

]
]LIST

100  REM  PRINT DATA 3/1/81
110  REM  PROJECT ORION
120  DIM RN(1000), TN(1000)
130 D$ =  CHR$ (4)
132  DIM IRT%(300)
140  PRINT
150  INPUT "DO YOU HAVE A PRINTER
      ON LINE (Y, N)"; Y2$
160  HOME : VTAB 3
170  PRINT "TYPE (BYE) TO END
180  PRINT "CURRENT FILE ", NA$
190  PRINT
200  INPUT "DO YOU WANT A NEW FIL
     E (Y, N)"; Y$
210  IF Y$ = "BYE" THEN  GOTO 820

220  IF Y$ <  > "Y" THEN  GOTO 50
     0
230  INPUT "ENTER FILE NAME "; NA$

240 A$ = NA$
250  PRINT D$; "OPEN "; A$
260  PRINT D$; "READ "; A$
270  INPUT N$, CO, RC$, RC, N, DUR
280  PRINT D$; "CLOSE "; A$
290  PRINT "NAME "; N$, "COND.  "; CO

300  PRINT "SCHEDULE "; RC$; " "; RC

310  PRINT "TRIALS "; N, "REIN.  DUR
     .  "; DUR
320 A$ = NA$ + " INX"
330  PRINT D$; "OPEN "; A$; ", L10"
340  PRINT D$; "READ "; A$; ", R0"
350  INPUT DA, A8
360  PRINT D$; "CLOSE "; A$
370  PRINT "SESIONS "; DA, "TRIALS
     "; A8
380  INPUT "STARTING SESION NO.  "
     ; J
390 JJ = J
400  INPUT "ENDING SESION NO.  "; K
```

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```
404 PT(1,0) = 1:PT(2,0) = 1
410  IF J > 1 THEN JJ = J - 1
420  PRINT D$;"OPEN ";A$;",L10"
430  FOR I = JJ TO K
440  PRINT D$;"READ ";A$;",R";I
450  INPUT R1,R2,R3$
460 PT(1,I) = R1 + 1:PT(2,I) = R2
     + 1
470 PT$(3,I) = R3$
480  NEXT I
490  PRINT D$;"CLOSE ";A$
500  INPUT "DO YOU WANT TRIAL DAT
     A (T) OR IRT DATA (I) ";DA$
510  IF DA$ = "T" THEN A$ = NA$ +
     " DAT":SI = 10:L = 1: GOTO 5
     40
520 A$ = NA$ + " IRT"
530 SI = 5:L = 2
540  FOR I = J TO K
550  PRINT D$;"OPEN ";A$;",L";SI
560  FOR N = PT(L,I - 1) TO PT(L,
     I) - 1
570  PRINT D$;"READ ";A$;",R";N
580  IF L = 2 THEN  INPUT IRT%(N)
     : GOTO 600
590  INPUT RN(N),TN(N)
600  NEXT N
610  PRINT D$;"CLOSE ";A$
620  IF Y2$ <  > "Y" THEN  GOTO 6
     60
630  INPUT "DO YOU WANT DATA SENT
      TO THE PRINTER (Y,N)";Y$
640  IF Y$ <  > "Y" THEN  GOTO 66
     0
650  PRINT D$;"PR#1"
660  HOME : VTAB 3
670  PRINT "FILE ",A$
680  PRINT : PRINT
690  PRINT "SESSION ";I
700  PRINT "CONDITION CODE ";PT$(
     3,I)
710  PRINT
720  IF L = 2 THEN  PRINT "IRT TI
     MES ": GOTO 740
730  PRINT "TRIAL ";  TAB( 4);"RES
     P.  ";  TAB( 6);"TIME "
740  FOR N = PT(L,I - 1) TO PT(L,
     I) - 1
744  PRINT N;  TAB( 7);
750  IF L = 2 THEN  PRINT IRT%(N)
     : GOTO 770
760  PRINT RN(N);  TAB( 14);TN(N)
770  NEXT N
774  PRINT : PRINT
780  NEXT I
790  PRINT D$;"PR#0"
800  INPUT "PRESS RETURN TO CONTI
     NUE ";Y$
810  GOTO 160
820  REM  CALL MENU
830  PRINT D$;" RUN MENU"
```